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Reversible photo-switching in a cell-sized vesicle

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生体内では、脂質膜に埋め込まれた高分子の光異性化反応による構造変化が情報伝達などの重要な働きを引き起こしている。過去に光感受性分子を含んだベシクル（100nm 以下）での水分子や水溶性物質の膜透過率測定の報告があるが、形状の観察はほとんどなく研究は未だ初期的段階である。今回我々は、光感受性脂質とリン脂質 DOPC(dioleoyl-phosphatidylcholine) とを混合した細胞サイズのベシクルを作製し、顕微鏡による直接観察を試みた。トランス体からシス体への異性化反応によって、膜面の揺らぎの変化や楕円体と球が連なった形状との間の形態転移などが引き起こされることが分かった。発表では、異性化反応にともなう構成分子の分子断面積の増減を考慮した自由エネルギーにより、形態変化のメカニズムを議論する。

In biological systems, change in the conformation of photosensitive molecules embedded in membranes, such as rhodopsin etc., play important physiological roles. Many studies have been conducted to prepare artificial photosensitive vesicles, and have reported changes in the permeability of ions and/or water-soluble compounds across the membrane upon photo-isomerization. In these studies, small vesicles (~100 nm) have frequently been used, which implies that the direct observation of morphological change in individual vesicles is impossible. Unfortunately, these small vesicles are usually unstable due to their high curvature and undergo spontaneous changes such as fusion, breakdown, and aggregation even in the absence of external stimuli. In contrast, cell-sized vesicles ($\geq$10 μm) are rather stable and can be used as a suitable model system for observing transformational processes and biochemical reactions inside them in real-time.

In this study, we designed and synthesized a photosensitive amphiphilic molecule containing azobenzene (KAON12); the conformation (trans or cis) of this molecule can be switched by light (Figure 1-a). Cell-sized vesicles were prepared from dioleoyl-phosphatidylcholine, DOPC, and KAON12 through natural swelling ([KAON12]/[DOPC] = 60 M/100 M). Photo-isomerization induces a change in membrane fluctuation behavior or a morphological transition between ellipsoid and bud shapes, depending on the asymmetrical degree of the initial shape. Figure 1-b shows the results of the photo-irradiation on an asymmetrical vesicle. After UV irradiation, the asymmetric vesicle exhibits budding. Interestingly, the budded vesicle transforms back to the original ellipsoidal shape upon treatment with green light. This reversible change in morphology

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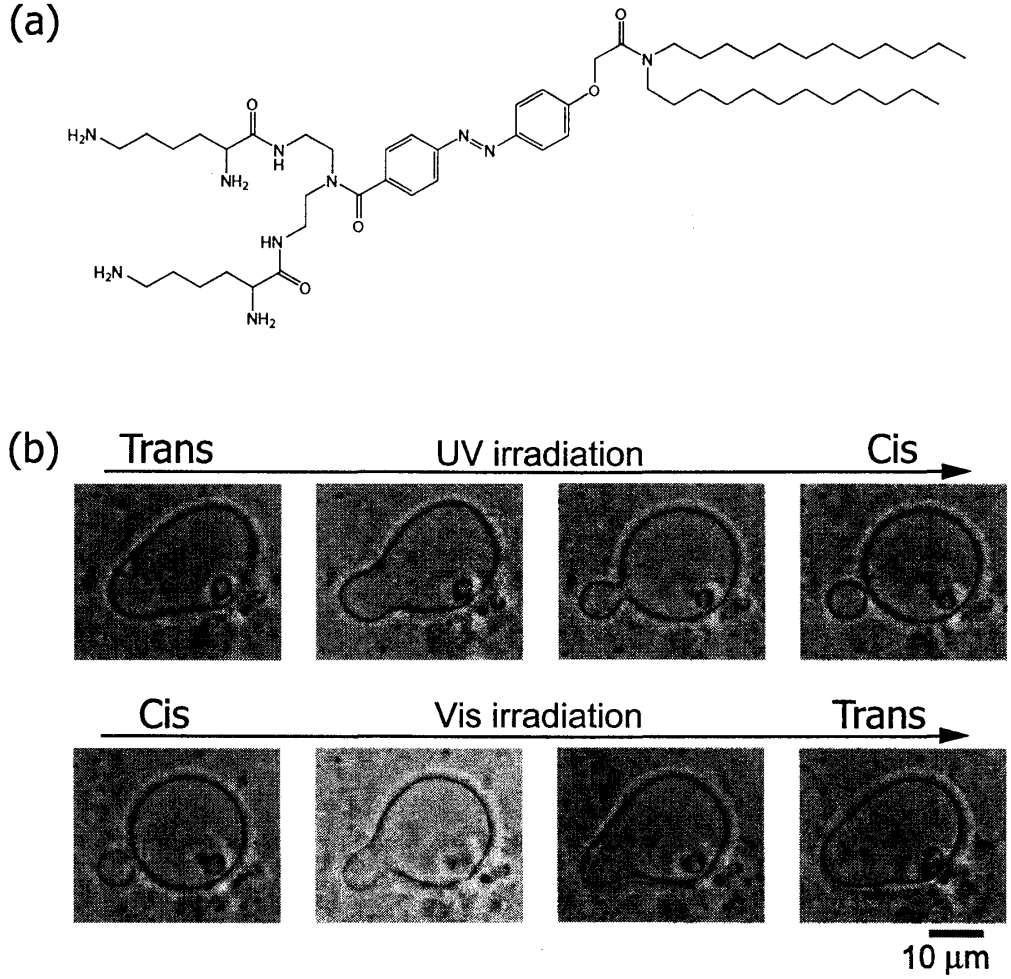

Figure 1: (a)Chemical Formula of KAON12. (b)Photo-induced reversible ellipsoid-bud transition in a cell-sized vesicle. The transformation from ellipsoid to bud induced by UV light is shown (Upper). The reverse process from bud to ellipsoid induced by irradiation with green light is shown (Lower).

is observed more than ten times. While the pathways of the transformation are different somewhat between the forward and reverse processes, the switching between the two stable states is reversible. We evaluate a change in membrane area during photo-isomerization by measuring Π-A curve, and discuss the mechanism of this reversible photo-switching in the vesicle morphology in relation to the effective cross-sectional area of the photosensitive molecule.

References

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